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SOME PHILOSOPHIC ASPECTS OF SCIENTIFIC RELATIVITY

IT is perhaps not altogether premature to attempt to outline some of the essentially philosophic aspects of the recent development of the physical theory of relativity, if only because of the extravagances in which both popular and scientific "philosophy" have indulged. Perhaps not since the Darwinian controversy have concepts so fundamental been subjected to criticism; and the reason for this is simple. All the basal elements of the purely scientific theory itself are identical with many of the central concepts of philosophy—space, time, simultaneity, motion; even the mere name itself, relativity, is sufficient to arouse the pugnacious instincts of every true philosopher. Confusion therefore is more than usually possible, and thinkers may again, as was the case with evolution, be drawn away in a vain pursuit of philosophic jack-o'-lanterns. The moral (if I may venture to suggest it) is obvious; there should be a much closer connection between philosophy and science. It is true that every step in advance makes this more difficult to achieve; but as things are at present, the results of scientific research far too often fall like a bomb into the philosophic camp, with dire results to its traditional serenity; as for the philosophies of scientists themselves, perhaps the less said the better. But Philosophy, it must be remembered, holds an inalienable lien on the whole of experience; which in its scientific aspects is fast becoming exceedingly complex.

As I have already suggested, the term "relativity" itself accounts for much of the prevailing confusion. It is absolutely essential to disregard, at all events to begin with, its long and involved philosophic history, and to use it, completely devoid of philosophic import, as it was employed originally with a purely scientific and quite definite meaning, which implied nothing more than that the observation of phenomena is determined only by the observer's velocity relatively to the observed system.[1] Even its widest later applications are concerned only with the relative velocities of systems and observers, and with the mathematical and other scientific (but not philosophic) implications of these. It is therefore vitally important to bear in mind that the theory has, to begin with, no bearing whatever upon the problems of the relativity of knowledge, of knower and known, or on the subjectivity, in the Kantian or any later sense, of Time and Space. So far as these questions are concerned, matters stand as they did previously; no school of thought is entitled (so far) to find in the scientific results any support, much less any conclusive proof, for its particular contentions; philosophically the formation is "as you were."

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[1] Campbell, *Modern Electrical Theory,* p. 381. Cunningham states this in terms of objects and ethereal media *Principle of Relativity,* p. 155.

A second source of obscurity has lain in the apparent self-contradictory character of the theory; a defect, however, which is wholly due to omissions in its exposition, and which is removed entirely when all the facts are considered. Simultaneity, it is stated, has lost its meaning; one and the same event, again, may be both before, and after, another event; even objective[2] space may be "warped." The illogicality of these statements, in this form, is evident; but it is not peculiar to them alone, for every partial truth, expressed without its necessary qualifications, is similarly illogical. But if we say, with greater accuracy and completeness, that events simultaneous for one observer are not therefore necessarily so for another; or that what is "before" for *A* may (or must) be "after" for *B*, or even for *A* himself when certain conditions of his observation change; or that an imaginary space-time continuum may be heterogeneous; or that "motional phenomena become timeless phenomena in four-dimensional space";[3] we merely generalize a principle which is frequently a matter of ordinary simple experience, as when the flash and report of an explosion are simultaneous for one observer but not for another, or when a spatial figure expresses a temporal process.

But the delicate phenomena and refined calculations which are involved are both so remote from ordinary intelligence that it is exceedingly difficult to form any conception of the actual concrete bearings of the theory; it is plainly impossible to construct any image of the velocity of light or the size of an electron; but these are after all obstacles rather of practical experience than of pure theory; and if the new principles could be applied to familiar occurrences the greater part of their mystery would disappear.

Such an application becomes possible if we imagine two observers who have always been completely blind, and whose knowledge of distant phenomena depends wholly therefore on their sense of hearing. Consider, *e.g.*, simultaneity and synchronism, and the fact that a clock which is at rest relatively to a normal observer and is ticking uniformly, will, if it moves continuously away at a fixed speed, thereupon tick for him at a slower rate, if he remains at rest and all other conditions are unchanged; in other words, if the clock while at rest (relatively to him) kept exact time with his watch, it would, while moving away, lose time as compared with his watch; but the velocity of light naturally makes the actual observation of this impossible.

[2] Objective, *i.e.*, as content of experience; but I should not myself question the wider "realist" position.

[3] Cunningham, *op. cit.*, p. 191.

But instead of clock and watch, let us take two automatic guns firing simultaneously, and with exactly the same intervals between the reports when they are close together and also close to an observer. If now one gun remains in position still close to the observer, while the other moves quickly away, it is obvious that the simultaneity will cease, and a longer and longer interval will elapse between the reports from the near gun, and the corresponding[4] reports from the distant moving gun; which means that the rate at which the observer heard the moving gun fire would alter; it would lengthen as compared with that of the fixed gun, which latter would thus come to fire (apparently) at a faster rate than its moving fellow. On the other hand if a second observer accompanied the moving gun his experience would be directly converse; to him the stationary gun would appear to fire more slowly than his own; and again if both observers with their respective guns were moving in varying directions and with varying velocities relative to each other, the comparative time-keeping of their guns would vary correspondingly.

Thus the two guns with their audible reports take the place of the two timepieces with their visible dials; and here it may be argued by the philosophically minded that the audible phenomena are mere "appearance" and that the guns "really" still retain their original synchronous firing. Now in one sense this argument is quite valid; but in another it is not; for its validity depends on all the conditions which ultimately determine human experience. To the normal observer, who can both hear and see, this contrast between reality and appearance is both inevitable and justifiable. But we have supposed our two observers to be congenitally blind, to lack therefore all experience of light phenomena and visible motion, and to derive all their knowledge of distant phenomena solely from the sense of hearing. For them therefore there can arise here no distinction between reality and appearance; what is heard is "real," and the audible differences in the firing rates of the two guns actual and ultimate.

Now these differences (audible, but to the blind observers real) depend on the velocity of sound waves; and all that the theory of relativity does is to trace and calculate the analogous consequences which the velocity of light must produce in normal human experience. If we substitute clocks for guns, sight for hearing, and the velocity of light for that of sound, there must arise an analogous discrepancy between the time rates of moving clocks, and therefore

[4] Corresponding that is in serial order, and disregarding fortuitous coincidences arising from the transmission of sound; as well as the assumption that the velocity of light is everywhere and always a constant; this prevents the light phenomena being *strictly* analogous to those of sound.

further, since all our measurements are normally based on time and space measurements, between physical phenomena when observed by different observers who are in different physical systems moving relatively to each other. In normal experience, vision corrects hearing; but we possess no sense faculties whatever which can in a similar manner check and correct the conscious experience derived through sight. That experience is ultimate for us, exactly as hearing is ultimate for our blind observers; no distinction between reality and appearance can possibly arise; what "really" happens[5] is what light phenomena reveal to us as happening; and then the scientific principles of relativity must be taken into account if our observations and calculations are to accord with "reality." They are no more illogical, contradictory, or revolutionary, than the theories of Copernicus, Galileo, and Newton; they merely, as these did, further correct the rough verdicts of our unrefined experience and yield exacter laws whereby we must express the content of that experience.[6]

Indeed, the principle, in spite of its name, does not even imply that we are wholly deprived of absolute standards; it merely means that we are free to determine these as we please, provided we accept *all* the results of our choice; it follows further that a proper selection will greatly simplify argument and calculation. Thus the "proper time" (*Eigenzeit*) of a system with reference to which a body is "at rest," as measured by observers moving with the body,[7] is unvarying and in that sense absolute; and Professor Eddington maintains that "One part of the World differs from another—an intrinsic absolute difference . . . the equality of two tensors in the same region is an absolute relation . . . the vanishing of the left-hand side denotes a definite and absolute condition of the World."[8] Just as sight would discover an "absolute" to our supposed blind observers, so thought may attain an absolute which is truly such for normal experience.

Nor again does the manner in which the theory treats simultaneity and other space and time attributes justify the contention that space is "warped," or afford the slightest fresh ground for the view that it and time are subjective. Some recent thinkers who have previously held this position now appear to regard it as finally established; while "realists" (so far as I know) have done little to question this attitude. But both schools alike, I think, have fallen victims to a profound misconception, which many scientists (particularly mathematicians) have avoided. They have overhastily confused the mathematical concepts which represent certain *abstract aspects* of time and space with those entities themselves as ontological; and thus the continuous variance of the space-time continuum in a field of force is expressed as a "bending" or "warping" of space, and the dynamic equivalence between gravitation and acceleration (expressed by the Principle of Equivalence) is represented as being the active operation of space-time itself; thus Russell: "attributing the phenomena of gravitation to properties of the space-time belonging to a gravitational field."[9] But any such extensions of the scientific theory are as yet wholly illegitimate, and certainly find no grounds in the work of its founders; it would be as logical to argue that because a curve may represent a changing force, therefore energy and time must be distorted. Philosophic arguments are (so far) scarcely affected in any degree, and upholders of neither the subjectivity nor the objectivity of time and space derive much if any support for their views from the new developments, if these are confined within their proper limits.

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[5] *I.e.*, in actual observation. We can still go beyond this in thought, but then the very data on which thought operates are derived from observation. *Cf.* previous note on the velocity of light.

[6] Contrast Bertrand Russell—"Demands a revolution in our conceptions of space and time" (*English Review*, Jan., 1920, p. 11); and Eddington—"The theory has introduced new conceptions of time and space," *Mind*, April, 1920, p. 145.

[7] Therefore of course themselves "at rest" in that system.

[8] *Loc. cit.*, pp. 148, 150, 151. The "World" is "the aggregate of all the point-events" (p. 147).

Thus Cunningham begins by insisting on the necessity of "drawing a clear distinction between the mode of *measurement,* and the *nature* of space and time"; the theory "emphasizes the derivative nature of *metrical* space and time, though it has nothing to say against the reality of perception—is completely dependent on such perception." But when thought analyzes the content of this perception, it is possible for it to detach certain purely abstract aspects, so that *e.g.* "in the four- dimensional world of Minkowski space and time combine into a single *concept"*; and this Cunningham rightly terms "the introduction of *mind-stuff,"*[10] a perfectly logical procedure if we but remember the character of what is thus introduced and refrain from objectifying its necessarily imaginary attributes. For the "four-dimensional world of Minkowski" is not a universe which is more truly real than the spatio-temporal world of perceptual experience; it is merely one which may be (in thought) substituted for either of two relatively moving physical systems, so that motion in that system, when observed from the other, must be regarded as occurring in this imaginary four-dimensional space-time concept and correctly calculated only on that supposition.[11] Thus "space and time become particular aspects of a single four-dimensional concept, and the motion of a point in time is represented as a stationary curve in four-dimensional space''; and exactly in the same way ''force and its rate of working may combine into a single concept in which distinction [is] lost, emerging only when we again separate space and time;'' or in general, ''All relations shall be vectorial relations in four-dimensional space.''[12] It may be worth remarking that a ''dimension'' is any definite concept, which may (further) be absolutely defined in terms of simpler concepts (dimensions), and which when combined, as thus defined, with number, may constitute equations; time and space therefore are themselves merely instances of the general class of ''dimensions'' as a whole.

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[9] *English Review,* Jan., 1920, p. 14.

[10] *Principle of Relativity,* Pref., pp. 8, 156, 87; italics mine.

[11] The imaginary element appears in the employment of $\sqrt{-1}$ in dealing with the time coördinate.

These methods and principles, however, do not affect in the remotest degree the philosophic problems of objective reality, the pros and cons of which remain what they were before; they merely express the laws which relate the appearances of such reality to different observers, or to the same observer under different sets of conditions. That different conditions necessitate different appearances of one and the same reality is almost a philosophic axiom; but the discovery that ''We may not conceive of a body as having physical reality unless the velocities of a given point as seen by two different observers are related by Einstein formulæ''[13] is not in itself sufficient to revolutionize our previous conceptions of the nature of that reality. In the same sense ''Riemann never speaks of space itself as being non-Euclidean. He carefully refers always to metric relations.''[14]

This consideration applies even to that most elusive of all physical reals, ether. It is notorious that it has hitherto proved impossible to attribute to it properties free from self-contradiction when taken all together; and it may be completely dispensed with when phenomena are reduced to the abstract level of motions which, as occurring in different physical systems, are expressed by Einstein formulæ. But with the reintroduction of energy and its correlative concepts conditions are profoundly different; ''the propagation of light . . . will always be sufficient ground for belief in some reality by means of which the transmission is effected. The ether must be rehabilitated.''[15]

Precisely the same holds true, *mutatis mutandis,* with regard to gravitation. The famous Principle of Equivalence is exactly what it professes to be and nothing more—a principle of equivalence, but not therefore of explanation. That changes in a gravitational field may be equally well expressed in terms of accelerations neither explains gravitation nor explains it away; as Brose points out, "Einstein does not seek to build up a model to explain gravitation, but merely proposes a theory of motions. He does not discuss forces as such."[16] Whatever gravitation is due to, it produces (of itself) accelerated motions which, when in different systems, are related by the formulæ of Einstein and Minkowski. If therefore within a non-gravitational system of bodies a gravitational field is suddenly created, an additional acceleration factor is thereby introduced into all the preëxisting motions, and the paths of light rays which previously appeared straight thereupon appear to be bent in varying degrees; and this change must appear to be ultimate because of the fundamental rôle, already alluded to, played by light and vision in normal experience.

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[12] Cunningham, *op. cit.*, pp. 191, 157, 113.

[13] *Ibid.*, p. 162.

[14] *Nature*, May 20, 1920, p. 351.

[15] Cunningham, *loc. cit.*, p. 29. *Nature, loc. cit.*

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REVIEWS AND ABSTRACTS OF LITERATURE

The Making of Humanity. ROBERT BRIFFAULT. London: George Allen and Unwin Ltd. 1919. Pp. 371.

This volume is devoted to the thesis that human evolution is the making of humanity, and that rational thought is the primary means of this progress. By human evolution is meant the natural growth of human life from "troglodytic man" to a rationally organized social life which shall satisfy the demands of human life. And by humanity is meant this organized whole of human life, which is a real organic unit over and above the individual human organisms which compose it. This organism of humanity is, however, not something already existent as a finished fact, but something in process of making. The author's purpose is to describe *how* it is being made. This description naturally takes the form of a philosophy of history. The problem is: What has been the constant factor, the real cause of human progress?

Mr. Briffault briefly criticizes the "endogenous theories" which attempt to explain human progress by man's mental capacities or by his racial characteristics on the ground that since they neglect to take into account the conditioning factors of man's environment they merely argue in a circle. Human progress is not explained by arguing that man is by nature a progressive animal. "A real se-

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[16] *The Theory of Relativity*, pp. 24, 25.